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審査請求　未請求　請求項の数 1　（全4頁）

㊹発明の名称　光検出器

㉑特　願　平2－216776
㉒出　願　平2(1990)8月17日

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明　細　書

発明の名称

光検出器

特許請求の範囲

ＰＮ接合を少くとも有する光電変換器の光入射部前方に、電流注入手段または電界印加手段を有する半導体層で成る光吸収量可変の光減衰器をモノリシックに形成したことを特徴とする光検出器。

発明の詳細な説明

〔産業上の利用分野〕

本発明は光通信に利用される光検出器に関する。

〔従来の技術〕

光通信システムは長距離・大容量を特徴とした幹線系光通信システムから、短・中距離，中容量の加入者網、またはローカルエリアネットワーク（ＬＡＮ）にまで浸透しはじめている。幹線系光通信システムでは、中継距離を最大にするために、受信系における光検出器への受光電力は、最小受光感度に余裕をもたせた受光電力になる様にシステム設計がなされる。これに対し、加入者系光通信システムでは、伝送距離は比較的短かいため、受信系における光検出器への受光電力は比較的大きいことがあり、光検出器の線形応答領域、あるいは、前段増幅器の線形応答領域からはずれることがしばしばあった。

〔発明が解決しようとする課題〕

従来の光検出器は、ＰＮ接合を有する光電変換器で構成されているため、光検出器もしくは前段増幅器の動作点が線形応答領域からはずれると、受信波形が歪み、誤りを発生する原因となる。従来、このような大きな光入力があった場合での受信波形の歪みを軽減するために、第3図に示すように、入力トランジスタ25のＤＣレベルを制御する手段（本島ら：1990年電子情報通信学会全国大会予稿集Ｂ－922）等がとられてい

た。ところが光検出器２０の線形応答領域を越える光入力があった場合に受信波形歪みを防ぐことが難しかった。

〔課題を解決するための手段〕

前述の課題を解決するために、本発明では光電変換器の光入射部分の前方に、光減衰量可変な半導体光減衰器を前記半導体光電変換器と同一半導体基板上に形成されていることを特徴とする構成を採ることによって、大きな光入力に対する線形応答を確保している。

〔作用〕

次に本発明の作用を第２図を参照にして説明する。光ファイバ１０より出射した光は光検出器１７の半導体可変光減衰器１１を通過した後、光電変換１２に入射する。光電変換器１２により光信号は電気信号に変換され、変換された電気信号は電流検出器１３により光電流量が電圧値として検出される。検出された電圧値は差動増幅器１４により基準電圧V_{ref}と比較され、基準電圧を上回る光入力が検出されたときは、可変光減衰器１１にさらなる電圧が印加されて可変光減衰器１１における光減衰量が増加する。

以上述べた作用により、本発明の光検出器を用いた光受信器では、光検出器や前段増幅器の線形応答領域を上回る強度の光入力があった場合に可変光減衰器により、光信号が光電変換器に入射する前に光電力を線形応答領域に調整するため光電力に対して、大きな線形応答ダイナミックレンジを有した光信号検出が可能となる。

〔実施例〕

次に本発明の実施例について、第１図を参照にして説明する。第１図は本発明による可変光減衰機能つき光検出器の実施例を示す断面図である。硫黄（Ｓ）ドーピングＮ型（１００）ＩｎＰ基板３０上に１．３μｍ帯用２次の回折格子３５（ピッチΛ＝７４３０Å）を長さ１００μｍにわたり３５０μｍおきに電子線ビーム露光及び化学エッチングの技術を用いて形成する。次にＩｎＰ基板３０上に光導波吸収層３１〔組成：ＩｎＧａＡｓＰ（λ_g＝１．３μｍ），厚み：０．２μｍ〕，光吸収層３４〔組成：ＩｎＧａＡｓＰ（λ_g＝１．３μｍ），厚み：０．５μｍ〕を順次気相成長法（ＶＰＥ）により成長する。次に前記１．３μｍ帯用２次の回折格子３５の存在する部分のみ光吸収層３４を残して、その他の部分の光吸収層をフォトリソグラフィー及び化学エッチングにより選択的に除去する。次にＰ型ＩｎＰクラッド層〔厚み：１μｍ〕を全面にわたって成長する。このとき、光吸収層３４の上に成長したＰ型ＩｎＰ層３２が光導波吸収層３４の上に成長したＰ型ＩｎＰ層に比べて山状に高く成長した場合は、山状に高く成長したＰ型ＩｎＰ層３２を選択的にエッチングにより除去し、表面を平坦化する。平坦化したＰ型ＩｎＰ層３２の上には、Ｐ型コンタクト層３３〔組成：ＩｎＧａＡｓ，厚み０．２μｍ〕を全面にわたり成長する。さらに、光電変換器領域３９と可変光減衰器領域４１の電気的分離をとるため、光電変換器と可変光減衰器の間、長さ５０μｍにわたり、光導波吸収層３１に至る深さまで、Ｐ型コンタクト層３３，及びＰ型ＩｎＰ層３２を選択的に化学エッチングにより除去する。さらに、光電変換器と可変光減衰器の電気的分離のために形成した長さ５０μｍの溝部分（素子分離領域４０）に鉄（Ｆｅ）ドープＩｎＰ層３８を１．２μｍ選択的に埋め込み成長する。次に、電極３７，３６をＩｎＰ半導体基板側及びＰ型コンタクト層側に形成し、Ｐ型コンタクト層上に形成した電極３６で、鉄ドープＩｎＰ層３８上の電極を選択的に除去し、電極アロイプロセスを経て、全作製プロセスを終了する。

以上記述した可変光減衰機能つき光検出器では、フランツケルディッシュ効果により光電力の減衰した光信号は、光電変換器領域３９に設けられた２次の回折格子３５によりＩｎＰ基板３０に対し、垂直に回折する。

２次の回折格子３５により回折した光は光吸収層３４により光電流に変換される。したがって、本実施例で述べた可変光減衰機能つき光検出器により光電力に対して広いダイナミックレンジを有した線形光検出が可能となる。

〔発明の効果〕

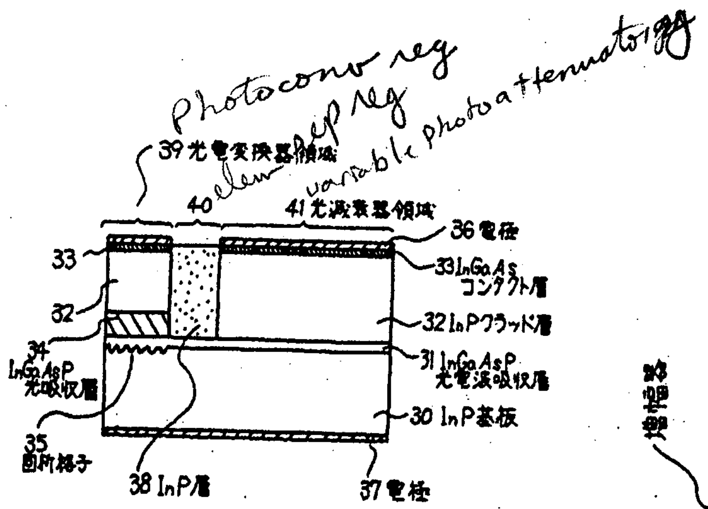
以上説明したように本発明によれば、光電力に対して広いダイナミックレンジを有した線形光検出を実現することができる。

図面の簡単な説明

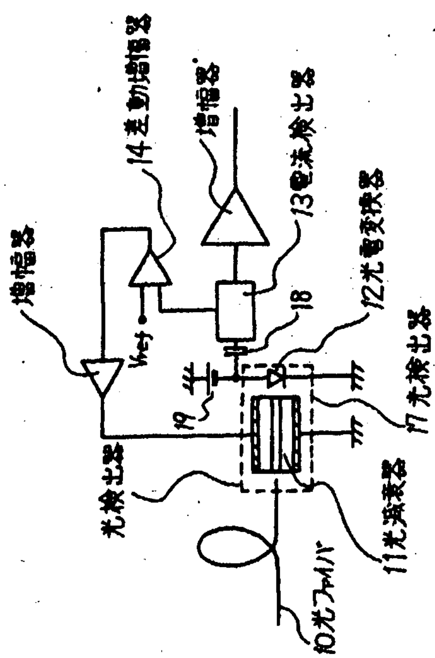
第1図は本発明による可変光減衰機能つき光検出器の構造を示す実施例の断面図、第2図は本発明による可変光減衰機能つき光検出器を用いた光受信器の構成を示す図、第3図は従来の光検出器を用いた広ダイナミックレンジ光受信器の構成を示す図である。

10…光ファイバ、11…可変光減衰器、12…光電変換器、13…電流検出器、14…差動増幅器、17…可変光減衰機能つき光検出器、20…光検出器、25…電界効果トランジスタ、30…InP半導体基板、31…光導波吸収層、32…P型InP層、33…P型コンタクト層、34…光吸収層、35…2次の回折格子、36…電極、37…電極、38…半絶縁性半導体層、39…光電変換器領域、40…素子分離領域、41…可変光減衰器領域。

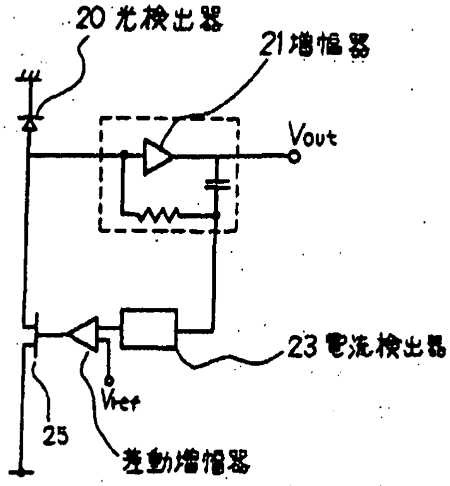
代理人　弁理士　内原　晋



第1図



第2図



第 3 図

PTO: 2001-4447

Japanese Published Unexamined (Kokai) Patent Application No. H4-98880, published March 31, 1992; Application No. H2-216776, filed August 17, 1990; Int. Cl.^{5}: H01L 31/0232 G02F 1/025 H01L 31/10; Inventor: Yoshihiro Koizumi; Assignee: NEC Corporation; Japanese Title: Hikari Kenshutsuki (Photodetector)

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1. Title of Invention

Photodetector

2. Claim

A photodetector, characterized in that a photoattenuator that can change the amount of a light absorption is monolithically formed in front of a light entering unit of a photoelectric converter with at least a PN bonding, which comprises a semiconductor layer and which possesses a current supply means or an electric field charging means.

3. Detailed Description of the Invention

[Field of Industrial Application]

This invention pertains to photodetectors that are used for optical communications.

[Prior Art]

Optical communication systems begin to diffuse from main line optical communication systems characterized by a long distance and a large capacity to subscriber networks at short and intermediate distances and an intermediate capacity or local area networks (LANs). In the case of the main line optical communication systems, the systems are designed so that light

receiving power in the reception systems to photodetectors has a free range given to a minimum light receiving sensitivity, in order to maximize the relay distance. In contrast, in the case of the subscriber photo communication systems, because the transmission distance is relatively short, light receiving power in the reception systems to photodetectors is sometimes relatively large. As a result, said light receiving power often deviates from linear response regions of the photodetectors or linear response regions of pre-stage amplifiers.

[Problem of Prior Art to Be Addressed]

Since prior art photodetectors comprise photoelectric converters with a PN bonding, when operating points of photodetectors or pre-stage amplifiers deviate from linear response regions, it causes a distortion and errors of receiving wave forms. In order to reduce the distortion of the receiving wave forms when such intense light is input, as shown in Fig.3, a means for controlling the DC level of an input transistor 25 (Electronic Information Communication Society: Spring National Meeting Proceeding Collection B-922, 1990, written by Motojima et al.) is used. However, when light that exceeds the linear response region of photodetector 20 is input, it is difficult to prevent the distortion of the receiving wave form.

[Measures to Solve the Problem]

The present invention ensures a linear response to an intense light input so as to eliminate said disadvantages, by taking a structure characterized in that a semiconductor photoattenuator that can change the amount of a photo attenuation is formed in front of the light entering unit of a photoelectric converter onto the same semiconductor substrate as that

of said semiconductor photoelectric converter.

[Effect]

The effect of the present invention is described next with reference to Fig.2. The light emitted from an optical fiber 10 enters a photoelectric converter 12 after it has passed a semiconductor variable photoattenuator 11 of a photodetector 17. A photo signal is converted into an electric signal by photoelectric converter 12. The photoelectric flow rate of said converted electric signal is then detected as a voltage value by a current detector 13. Said detected voltage value is compared with a reference voltage V rer by a differential amplifier 14. When a light input that exceeds the reference voltage is detected, additional voltage is charged to variable photoattenuator 11 so as to increase the amount of a light attenuation of variable photoattenuator 11.

With said effect, as for a photoreceptor that utilizes the photodetector of the present invention, when light that exceeds the linear response regions of the photdetector and the pre-stage amplifier is input, a detection of a photo signal that has a large linear response dynamic range in relation to photoelectric power is possible by the use of the variable photoattenuator so that said photoelectric power is adjusted for the linear response region prior to said photo signal enters the photoelectric converter.

[Embodiment]

The embodiment of the present invention is described next with reference to Fig.1. Fig.1 is a cross-sectional view illustrating an embodiment of a photoattenuator with a variable light

attenuation function of the present invention. A secondary diffraction grating 35 (pitch A = 7430Å) for a 1.3 μm band is formed onto a sulfur (S) doping N type (100) InP substrate 30 through a 100 μm length at 350 μm intervals by using an electron beam exposure and a chemical etching. After this, a photoconductive wave absorbing layer 31 [composition: InGaAsP (λs = 1.3 μm); thickness: 0.2 μm] and a light absorbing layer 34 [composition: InGaAsP (λs = 1.3 μm); thickness: 0.5 μm] are grown in the order by using a vapor phase epitaxy (VPE). While leaving light absorbing layer 34 only on a part with secondary diffraction grating 35 presented, said light absorbing layer on other parts is selectively removed by a photolithography and a chemical etching. Following this, a P type InP clad layer [thickness: 1 μm] is grown on the entire surface. At the time, if P type InP layer grown on light absorbing layer 34 is grown in the form of a high ridge in comparison with the form of the P type InP layer grown on photoconductive wave absorbing layer 31, P type InP layer 32 grown into a high ridge is selectively removed by an etching, so as to flatten the surface. A P type contact layer 33 [composition: InGaAs; thickness: 0.2 μm] is grown through the entire surface of flattened P type InP layer 32. In order to obtain an electrical separation between a photoelectric converter region 39 and a variable photoattenuator region 41, P type contact layer 33 and P type InP layer 32 are selectively removed up to the depth reaching photoconductive wave absorbing layer 31 through a 50 μm length between the photoelectric converter and the variable photoattenuator, a chemical etching. An iron (Fe) dope InP layer 38 is further selectively embedded and grown at 1.2 μm in a groove (an element separation region 40) of a 50 μm length that is formed for an electrical separation of the photoelectric converter and the variable photoattenuator. After this, electrodes 36 and 37 are formed onto

an InP semiconductor substrate side and a P type contact layer side. An electrode on iron dope InP layer 38 is selectively removed with electrode 36 formed on the P type contact layer. After an electrode alloy process has been taken, all of the production processes are completed.

As for the photodetector with the variable light attenuation function as described above, a photo signal with an attenuated photoelectric power is diffracted vertical to InP substrate 30 due to a Franz-Keldysh effect, by using secondary diffraction grating 35 provided in photoelectric converter region 39.

Said light diffracted by secondary diffraction grating 35 is converted into photo current with light absorbing layer 34. As a result, a linear photo detection with a large dynamic range for photoelectric power is possible by using the photodetector with the variable light attenuation function as described as in the embodiment.

[Advantageous Result of the Invention]

As described above, according to the present invention, a linear photo detection for photoelectric power can be achieved, which has a large dynamic range.

Brief Description of the Invention

Fig.1 is a cross-sectional view of an embodiment illustrating a structure of a photdetector with a variable light attenuation function of the present invention. Fig.2 illustrates a structure of a photoreceptor that uses the photodetector with the variable light attenuation function of the present invention. Fig.3 illustrates a structure of a large dynamic range photoreceptor that uses prior art photodetector.

10...Optic fiber

11...Variable photoattenuator

12...Photoelectric converter

13...Current detector

14...Differential amplifier

17...Photodetector with a variable light attenuation function

20...Photodetector

25...Field-effect transistor

30...InP Semiconductor substrate

31...Photoconductive wave absorbing layer

32...P type InP layer

33...P type contact layer

34...Light absorbing layer

35...Secondary diffraction grating

36...Electrode

37...Electrode

38...Semi-insulating semiconductor layer

39...Photoelectric converter region

40...Element separation region

41...Variable photoattenuator region

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Chisato Morohashi